

# THE EFFECT OF ALTITUDE ON THE RAINFALL AMOUNT ON NORTHERN IRAQ

\*Prof. Dr. Qusay Abdul-Majed Al-Samarie, \*\*Assist. Prof. Dr. JwanSameen Ahmed

\*College of Arts \ Dept. of Geography.

\*\*College of Education IbnRushd \ Department of Geography University of Baghdad.

## ABSTRACT

*The location of Iraq is within the desert region of little amounts of rain. Its rainfall system is part of the Mediterranean rainfall system where the rainfall starts in October and ends finally in early June. The reduction of rainfall in Iraq is attributed to its location, hence, the topography plays an important role in the variance of rainfall in different locations of the country. In the topography of Iraq plain with no height the place discrepancy in the rainfall amount would be little as in the middle and the south regions where the rainfall discrepancy is very little. Thus, the northern region of Iraq is considered as rain oasis in desert region. It is important to determine the altitude contribution in the increase of rainfall. Although the climate studies approve the effect of altitude in increasing rainfall amount, the amount of this increase is different pursuant to the location and the climate of the region. Thus, it is necessary to determine the contribution of highlands in the amount of rainfall in Northern Iraq. The highland is distinguished by climate variance that effect on all the climate elements. The climate discrepancy in the mountain region take vertical not horizontal sample as occurs in the plain region. Thus, it is probable to find more than one climate region in one place of great height. When it is found the temperature takes one sample in its reduction with the altitude, the rainfall does not have this sample. Thus it required that each region is studied alone to search the sample of rainfall increase by the altitude of this region .*

The altitude of rainfall amounts on the north of Iraq makes it a distinguished climate region and that makes its agriculture, tourism and water capabilities great .The northern region depends in farming on rainfalls and it has successful tourism abilities specially in summer .Also it provides great amounts of water to Tigris river and that gives this region exceptional climate importance and all that is due to its altitude .Thus this study attempts to answer the following questions :

- 1-What is the most important elements effecting on the altitude o rainfalls amounts ?
- 2- What is the rate of altitude contribution in rainfalls increasing ?
- 3-What is the amount of increase in rainfalls by the altitude ?

To answer these questions the following hypotheses were made :

- 1-The altitude has the greatest rate in rainfall increase .
- 2-There is positive correlation relation between the altitude and the amount of rainfalls .
- 3-The average of increase amount of rainfall could be determined for each 100 m altitude of the region .

## THE RESEARCH METHODOLOGY

The statistics of the annual rainfalls amounts were collected from 31 stations spread in good manner in northern region (figure1) .Although there are no continues records from these stations but four years of good records from 1976 to 1979 were acquired .thus the analyses was limited one year but on several years because the rainfalls in this region was swinging .To reduce the effect of swinging more than one year were chosen to use their averages .Simple correlation coefficient to find the correlation relations between the altitude and the amount of rainfalls the value of ( $r^2$ ) to express the percentage of altitude contribution in rainfall increase . In order to account the expect increase amount per 100 m the rainfall average was concluded for each station for the four years used in the research .The rainfall average was concluded for each level ( level 200 and 300 to the level 1299 ) . Then the average was concluded between each two level respectively (conclude the average between the average level 200 and the level 300 and between 300 and the level 400 etc .) and by subtract the level average from the precedent level average and conclude the difference between each two levels .As the increase is not equal for each level the increase and reduction level in all levels was concluded in all to reach a general average for increase to each level .For the purpose of analyses the increase of rainfalls in northern region and its difference from the other parts of Iraq the annual map of rainfalls published in Iraq climate atlas on 1989 was used .

## PREVIOUS STUDIES

Iraqi northern region was not analyzed in this way before .Also no individual study were made on the effect of the altitude .All the researchers who write about the rainfalls in Iraq take the subject in general .,when they talk about the northern region of Iraq the reference is only made about that the heavy rainfall in the region is because of the altitude .Thus we are going to mention only the researchers who wrote about the subject of rainfall in Iraq .Dr. Ali Shalash wrote about the rainfalls effectiveness in Iraq<sup>1</sup> and Mr. HarithDhahi wrote about Iraq rainfalls in MA thesis <sup>2</sup>.Also Dr. NumanShihatha determine the rainfalls and its concentration <sup>3</sup> .Dr. Ali Shaker Alnuaimy and others

---

analyzed the changes in the rainfalls amounts that accompany the air systems<sup>1</sup>. Hayfa' Taher and ImanMedhat studied Iraq rainfalls during the season 1980-1981<sup>2</sup>. NajimAbdulrahman has divided the rain group into ten days in Iraq<sup>3</sup>. Rainfall was also studied in climatic and hydraulic theses and dissertations. There are studies about the effect of rain as one of the element of water, which are studies that fall under the application of climate. Therefore, this study is a groundbreaking as far as the determination of the effect of altitude in amount of rainfall and in determining the increase level each 100 m. it is also the first study that uses the correlation relation to identify the altitude as a factor in rainfall on northern Iraq.

## OROGRAPHIC RAIN

Rain is a condensed evaporation of water in the air transformed into water droplets. The droplets accumulate to be heavier to be borne by air. Thus, they are dropped in the form of water drops on the surface. In our treatment of drops in this study, the falling snow will be referred to as 'rain' since it is ultimately transformed into rain because we are dealing with the amount of rainfall. For the evaporate water to turn into droplets, the rain must raise up so that its temperature is lowered than the levels of adiabatic lapse rate, in addition to the provision of condensation atoms and the existence of vapor in a sufficient amount in the air. Thus, the type of rain depends on the manner of raise of the air. In the conductive rain, air raised as a result of the heat of air either locally or by heating system like tropical storms. Frontal or cyclonic rainfall is the type of rain in which air rises up either from the center of the atmospheric depression or as a result of the meeting of two aerial masses along the front while the warm air mass raises above the cold air mass. In orographic rain air raises due to clash with height such as mountains or hills or the gradual rise in the land. Therefore, the manner of raise is mechanical as the element behind the raise is ever-present. When the other elements are available (such as sufficient amount of water vapor) rain can fall over the high land.

Terwaha<sup>4</sup> places topography in importance right after the distribution of water and land and then the amount of falling rain in similar latitudes. Topography plays a vital role in increasing the amount of rainfall. Its effect appears more clearly in the arid regions where high oasis. The following factors increase the amount of orographic rain<sup>5</sup>:

1-The start of air elevation when clashing with the high land and no air stability for wide area. Thus, the all is for two reasons: clashing the topography and heating.

2-As a result of friction with the topography and very rough surface, the surface storms and surface aerial depression and atmospheric grooves are slowing down increasing the amount of rain.

3-The variance of topography forms cause entrapment of air in some regions concentrate it and alleviate it which improve the ability of its falls .

4-The topography add rainfall to the region in addition to the storms and elevating rainfalls .For example if the nearby plane region has 200 ml ,the rainfalls above on the average .The add the mountain region shall be higher because of the topography adding more amounts of rainfalls .The added rainfalls increases with the increase of the height to certain limit .The average increase of the rainfalls begins to elevate 2-5% each 100 m altitude<sup>1</sup> .This rate of increase is not stable , not similar and not absolute .This increase begins to stop after reaching certain altitude .The continues increasing in altitude depends on the amount the water vapor on in the air .The more amount of vapor the higher the altitude level in which the rainfall amount increase .As a result to the temperature reduction by altitude , the ability of the air to carry the water vapor is reduced until the water vapor becomes very little .Thus the amounts rainfalls reduced with the increasing altitude .The level of in which the rainfalls begins to reduce is estimated between 1500 m- 3000 m <sup>2</sup> and there are even a locations that the rainfall reduced in low altitude .It is found that the rainfall reduced by altitude after the level 700m in Java<sup>3</sup> .The problem of topography is that they are not distributed equally .They are different vertically and horizontally .The vertical difference resulted from continuous altitude the air causing increase of rainfall amount to certain limit and it begins to reduce .The horizontal difference is caused when certain parts of the mountains region are under the shadow of the rainfall .The mountain chains when a certain direction of winds domains , parts of them become in front of the winds ,Thus the opposite foot become in the rainfall shadow .The rainfall reduced in rainfall shadow because the air after passing the mountain chains begin to fall which increase its temperature so the condensate stops except in the region in which the altitude increases than 2500 m <sup>4</sup> .The low altitudes are not enough to find rainfall shadow regions and that does not cause clear differences in the rainfall amounts on the various sides of the mountain chains .That appears clearly in in Northern Iraq .The medium altitude mountains and its separation led to disappearance of rainfall shadows .The rainfalls continue in increase as we go northeast direction .The in the rainfall amounts is natural and not because of the rainfall shadows.

## DETERMINE THE INCREASE AMOUNT

The simple regression was used to determine the best linear slop to express the relation among the studied variants .By using this method it was clear that the results were not suitable (High) and do not express the reality of increase by altitude .The analyses result was increase of rainfall 266 ml or each 100 m altitude and that is impossible .by searching in the statistics it was explained that the relation between the altitude and the rainfalls is not exactly linear .thus another mathematic method were used to determine the increase amount and divide the location altitudes to groups ,each group represent 100m .the station altitude begin with 200 m and end with 1299 m where the maximum altitude of the stations was 1210 .Thus the altitudes in the stations were divided into (11) groups ( table 3 ) .The average was concluded from each group of stations and as the average represents arithmetic mean o the group ,the average which represent the altitude from 200- 299 is the average that represent the altitude 250 m .thus the average was concluded from each close groups .The average was concluded between the group average 200 and the group 300 etc. to express the highest altitude in the group and not its arithmetic mean and subtract the highest altitude group average from the average of lowest altitude group to obtain the increase amount of the high altitude .The difference between the group average 200 and group 300 determine the increase or the first 100 meter and so on (table) .It is explained from the table that the increase of rainfall by altitude was not same for all levels .that approve what we reach before that the relation between the altitude groups and the rainfall averages and increase amounts of each group and its percentage with the increase average.

**Table 1 The relation between the altitude groups and the rainfall averages and increase amounts of each group and its percentage.**

Altitude	Average 4 years	The average mean	Increase amount per 100m	percentage
200-299	286.4	303.9		
300-399	321.4	434.8	130.9	30%
400-499	548.1	567	132.2	23%
500-599	585.9	612.1	45.1	7%
600-699	638.2	650.9	38.8	6%
700-799	667.5	665.3	14.4	2%
800-899	667	771,5	106.2	14%
900-999	876	877.3	105.8	12%
1000-199	878.6	806.7	60.6	7%
1199-1100	754,8	782.4	34.3	4%
1200-1299	810	810	27.6	3%

Resource ;The researcher work depending on the General Committee of Meteorology ,Ministry Transport and Communication 1998.

The increase average per 100m ,altitude 50.61m ,the altitude and amounts of rain is non-linear .The rainfall increased in the first 100 m in amount 130.9 ml meanwhile the increase in the second 200 m to a32.2ml which is the hast recorded altitude .The increase of rainfall by altitude began to slow after this altitude .The rainfall increased between the altitude 699 to 799 by 14.4 ml. The rainfall great increased between 799-999 .It increased above 100 ml per 100 m altitude .After this great increase the rainfall began to reduce .It reduced 6.6ml per 100m altitude between 999-1099 and 34.3ml per100m altitude between 1099-1199 .the rainfall amounts increased again in average 27.6 ml per 100 altitude in the last level .It is clear from this analyses the increase was not the same and the rainfall in certain altitude began to reduce in its increase .the reason behind this reduction is due to that the vapor amount in the air is not much enough for the increase of rainfall to continue with the increase of the altitude .The study emphasize on this fact in various parts of the world .Thus it is truth to say that the rainfalls begin to decrease after altitude 1000 m and there are no station above 1210, we have no information about rain amount in that level for the disorganization in the rainfall amount to give a reasonable impression about the increase. The level of increase was derived for all level and the result was an increase in the rainfall and dividing them on the number of these levels. The results was that the amount of increasing rainfall for every 100 m height which is 50.61 mm. By applying the average increase on a number of stations we find out that it gives certain results concerning the stations on which rain falls in amount close to the average amount of rainfall. Thus, it is possible to say that the amount of rainfall increases every 100 m height in Northern Iraq and it begins to decrease gradually after 1000m.

Northern of Iraq rain are in most parts are orographic rain in which the altitude contributes to the increase of rain amounts. Also another reason for the increase of rainfall is Northern Iraq is the universal rate of %2-5 per each 100m. All indicators that have been analyzed indicate that height in Northern Iraq increases the amount of rainfall on the region.

## **ANALYSIS OF THE STATISTICAL RESULTS OF THE RELATION BETWEEN ALTITUDE AND RAINFALL**

Simple correlation coefficient was used to determine the correlation relation between the altitude and the annual amount of rainfall. T-test was used to verify the result since as the data represent a sample and not a complete survey. All stations were admitted to the analysis since the available statistics for every year is not available for more than 26 stations. This is why a number of stations which the statistics is available per annum. The number of stations that have records for 1976-1978 are only 25 stations and 26 stations for 1977 and 24 stations for the stations that have the average rainfall for

these four years or less are 31 stations. It was used in second analysis as the following table. There is a positive correlation between the altitude and the amount of rainfall where (r) value ranges between 0.73-0.80. by using T-analysis it is clear that the calculated T-value is much higher than scheduled T-value. Thus the hypothesis accepts trust level 0.001.

**Table (2)****Statistical Result of the Correlation relation with altitude**

Year	r value	r <sup>2</sup> value	T <sup>1</sup> Calculated value	T <sup>1</sup> scheduled value	the hypothesis accepts trust level
1976	0.74	0.54	5.23	3.745	001
1977	0.73	0.54	5.27	3.725	001
1978	0.77	0.59	5.77	3.45	001
1979	0.77	0.59	5.64	3.767	001
Period average	0.80	0.60	7.18	3.646	001

To conclude the percentage of this coefficient contribution in the amount of rainfall, this coefficient contributed in %64 which is high to control the amount of rainfall in the northern region.

**RAINFALL IN IRAQ**

The location of Iraq is the southwest angle of Asia, between attitude 29° north and 37° north. Thus, it is located within the subtropical region which is controlled by the tropical high pressure in summer. The permanent tropical high pressure is moving northwards and southward with the sun movement. In winter their location average in the latitude circle 20-25 degrees north, and creeps northwards in summer and its average location becomes 35 degrees north. Because it is in summer become above the water more clear in the land, and the tropical high pressure has a wide range in the west, a tongue of tropical high pressure concentrated above the Atlantic ocean extended to the Mediterranean basin and the near, although it does appear on surface in summer according to the warming but it exists on altitude more than two thousands meters. Thus, Iraq like Mediterranean basin and the nearby lands, even though it does on surface in summer season as a result of warming, still exists in altitude more than 2000 meters. Thus, Iraq is subject to the influence of this pressure at least from altitude 700 billion (3000 meters). Hence, the rainfall stops completely in summer. Iraqi rainfall is subject to the system of Mediterranean rainfall which falls from mid-autumn to the late-spring. In general, the rainfall in Iraq is described as falling in the winter half of the year where the movement of subtropical high pressure southwards allows some areal depression that move in winter

to the south of summer location to pass over Iraq. Because the country is close to the edges of high pressures in winters, and the air temperature in winter is low, enabling air to carry water vapor low, the rainfall in Iraq is little. Iraqi climate is a desert climate in the Middle and Southern parts because the rainfall amount is much less than the annual evaporation. This process could cover most of Iraq area if the surface is plain but the topography in the northern part of Iraq is different.

The analysis of the amount of rainfall explains the influence of various elements that effect on determining the amount of rainfall (Map 2) . As the above mentioned, the geographical location of Iraq does not provide the conditions of rainfall in great amounts. Rain increases in Iraq northwards and the source of rain in Iraq is the Mediterranean and Sudanese depression . Medium depressions contribute to the biggest part of rainfall on Iraq. As most of these depression route goes towards the northern-east regions, the middle and northern parts of Iraq received more amounts of rainfall than the southern parts. However, the discrepancy the amount of rainfall between middle and south stations on one hand and the northern stations on the other hand is too wide to be explained in this phenomenon alone. Figure (2) explains that the rainfall in Iraq slowly and gradually increases the more we move from the south to the line that passes north of Beji to divide al-jazeera area into two parts

The permanent line of rains 200ml starts from south of Khanaqeen through north of Beji and the south of Qiara and Sinjar .Thus the region extends from Fao southward to the edges of the line 200 ml received amounts of rains between 75ml and 200 ml. Thus it is clear that all the sedimentary plain and most of and most of the west plateau and half of Aljazera area (three quarters of Iraq distance ) are located within this rainy area .The rainfalls begin to increase from the wavy area where the rainfalls on the area limited between wavy area and the foreign borders through Iran and Turkey in comparison with the rainfalls on the middle and south regions . The rainfalls average on the north region ranged between 200ml to 800ml and reached to more than 1000ml for some stations .Thus table 2 explains that the rainfalls equal lines are close with each other greatly in northern region and this closeness increased northward .That means the increase in the in rainfalls is in parallel with altitude increase .So the altitude from the sea level resulted in much increase of the rainfalls .The rainfall in the region do not increase because it fall within the rout of low depression alone .The altitude play an important role in change the air suitable condition that raise the air higher which evaporate its water which led to add mechanical element to raise the air through the depression low and the fronts .And because the topography work to slow the movement of air system passing through it because of the high hardness of the surface .Thus the rain which falls through air depression above the area are great than the rains the rains falls from the pass of the same low depression above the plain.

Comparison of the rainfalls in the various stations with its altitudes ,it is clear that the rain increases with the station latitude ( table 3).Before the detailed discussion we must indicate an important point

related to the table .The stations were chosen was on condition of the existence of records of the same years of more number of meteor and rainfall stations in the area . According to the security conditions the records of all stations were no continuous .So there were many lacks in the records .Even the long range in the table suffered from some defects. The general figure explained the increase of rainfall with the increase of altitude .the discrepancy between the stations which their altitude are high is due to the difference of the local conditions surround each station .For example ,the reason of the great altitude of Darbendikhan and Dukan in comparison with the stations that have the same altitude is the influence of Dukan and Darbendikhan on the rainfalls as the air could provide more water vapor .Also the form of topography such as concavity and convexity play a role in increase the amount of the rainfall .That mean the suppose that the conditions which surround the station is responsible of the difference of rainfalls among the one latitude stations

In an attempt to explain the variance in the rainfall amounts by station location in the rainfall shadow a contour map was used for the region to determine the areas that locate in in rainfall shadow .It was clear through the analyses that the stations which located on the winds opposite footage are received rainfalls more than the stations that located in the front of the winds and the same altitude .Thus it is explained that little altitude in the region ( not more than 2500 m) with separation in the mountain chain played an important role in absence of the stations that has the qualifications of rainfall shadow .Thus the influence of the altitude appeared in the rainfall increase on the all stations and the variance among the stations was for local conditions

Table (1)

**The annual of amount rainfall in millimeter and the period average and altitude in meter of hosen stations in Northern Iraq**

Stations	Height in meter	Amount of millimeter				Period average	Long-range average
		1979	1978	1977	1976		
Alkweir	214	382.2	-	-	298.6	3420.4	-
Mosul	222.6	390.6	430.3	261.9	335.1	332	378.6
Makhmor	270	-	262.5	144	213.4	206.6	-
Tellafar	273	360.7	259.3	153	329.2	275.6	337
Haweejah	305	296.1	236.1	144	217	223.3	280
HammamAlaleel	300	318.5	346.9	270	350.3	321.4	-
Kirkuk	330.8	351	343	243	292	308	375.7
Bashiqa	350	406.8	341.5	302.7	416.5	366.9	-
Smaeel	381	55.7	348.5	302.7	416.5	366.9	-

Drbindikhan	400	550.7	348.6	330.8	-	410	-
Irbil	414	453.3	410.8	381.8	381.3	375.8	405.3
Zakho	442	659.7	557.8	535.5	634.6	601.9	725.6
Dukan	459	848.5	706.5	641	-	732	772.3
Sinjar	476	436.4	331.1	187.7	340.6	323.95	493.8
AynSfeen	520	584.5	438	-	484.6	502.4	-
Alqosh	550	1002	814	516	331.5	665.9	-
Kweensjeq	610	-	-	567.3	709.1	638.2	-
Chemchamal	701	462.5	416.1	445.5	-	441.4	-
Aqra	716	805.2	736.5	769.2	813.4	781.8	1010.5
Hleibcha	730	767.8	508.8	-	-	638.3	649.7
QarahDagh	830	895.3	642.7	-	555.9	692	-
Suleimaniya	853	745	662.2	705.3	684	699	712.1
Dohuk	860	-	-	463.1	-	463.1	554.2
Shaqlawaa	920	1445.4	845	928.5	821.5	1010.1	1005.1
Maknash	980	625.7	591.7	-	-	608.7	-
Rawindooz	1006	963.9	859.7	755.5	-	859.7	910.3
Serank	1046	-	1070.4	843.6	1026	980	1020
Salah aldeen	1088	-	-	777.7	553.9	66.8	719
Bamerni	1099.5	-	-	-	799.6	799.6	-
Swarehtuki	1198.6	914	619.6	72	763.5	754.8	-
Al-Emadiya	1210	942.6	829.8	816.7	650.8	810	931.2

## REFERENCES

- 1- The Iraqi General Committee of climate prediction ,The records of rainfall station for the northern region for the periode1976-1979,unpublished records ,the department of water and agriculture prediction .
- 2- Ali Shalash the climate science , University of Baghdad printing House ,1979 ,p 27 .
- 3- HarithAbduljabarDhahi ,Rainfalls in Iraq ,A study in applicable climate .unpublished MA thesis ,University of Alexandria -College of Arts –Department of Geography 1989 .
- 4- NumanShihatha , Determinations of rainfall season in the east basin of the Mediterranean sea , Asia and Arabia ,the Magazine off natural sciences , geography of Jordan University ,Amman –Issue No. seven .
- 5- Ali Shaker Al-Nuaimy and Natiq Ahmed Zeky , NemaamehsinLafta , The changes in the rainfall amounts for the air systems on Iraqi country ,The Magazine of Mustansriya Science , Mustansriya , College of Science , Issue No, four ,1993 .

- 6- Hayfa'Taher Hussein and ImanMedhatNamiq, A study of the rain on select regions on Iraq, ministry of Transportation. 1980-1981, General committee for meteorology in Iraq, Regional Training meteorological Center, Scientific Publications (41) 1982.
- 7- Najim Abdurrahman , A study of the rain group into ten days in select regions on Iraq, ministry of Transportation. 1980-1981, General committee for Forecast in Iraq, Regional Training Forecast Center, Scientific Publications (4) 1984.
- 8- Ahmed SaeedHadeed ,Ali Shalash&MajidAlsaidWaly , Meteorology ,University o Baghdad Printing House , 1979 , p28 .
- 9 -Ministry of Transport and Communication , Iraqi Meteo General Committee, Atlas of Iraq Climate (1951-1980), , Republic of Iraq. Baghdad, 1979. .99.
- 10- Kadhum Al-Assady, Areal Depressions.
- 11- Glenn T Terwahya and Lyie H. Hovn. An Introductory to climate, fifth edition, Mewaeutill book Comp. New York, 1980, p.332.
- 12-John F. Griffith and Dennis M. Driscoll ,survey of climatology Charles Mervill pub, Compan, Columbus , Ohio 1982, ,p 160.
- 13-Griffith and Driscoll ,opcite ,p122.